EVALUATION KIT AVAILABLE

TC1026

Linear Building Block – Low-Power Comparator with Op Amp and Voltage Reference

FEATURES

- **Combines Low-Power Op Amp, Comparator, and Voltage Reference in a Single Package**
- **Optimized for Single-Supply Operation**
- **Small Package .... 8-Pin MSOP (Consumes Only Half the Area of an 8-Pin SOIC), 8-Pin SOIC, and 8-Pin PDIP**
- **Ultra Low Input Bias Current ..... Less than 100 pA**
- **Low Quiescent Current .... 12µA, (Typ.)**
- **Rail-to-Rail Inputs and Outputs**
- **Operates Down to V_{DD} = 1.8V, Min**

APPLICATIONS

- **Power Management Circuits**
- **Battery Operated Equipment**
- **Consumer Products**

GENERAL DESCRIPTION

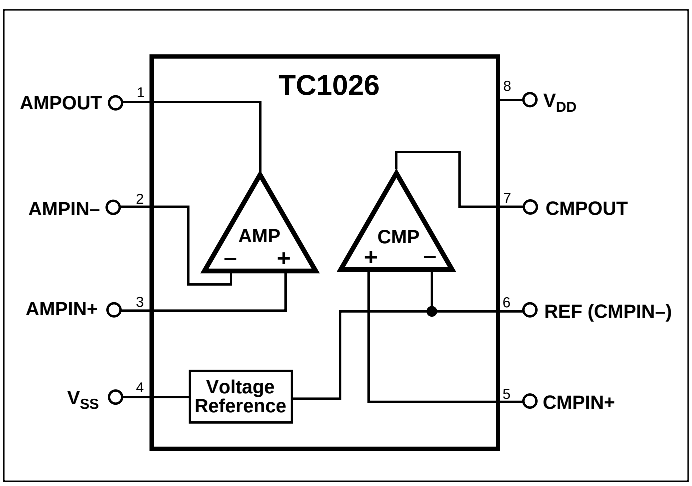
The TC1026 is a mixed-function device combining a general-purpose op amp, comparator, and voltage reference in a single 8-Pin package.

This increased integration allows the user to replace two or three packages, which saves space, lowers supply current, and increases system performance.

Both the op amp and comparator have rail-to-rail inputs and outputs which allows operation from low supply voltages with large input and output swings. The TC1026 is optimized for low voltage (V_{DD}= 1.8V), low supply current (12µA typ) operation.

Packaged in a space-saving 8-Pin MSOP, the TC1026 consumes half the board area of an 8-Pin SOIC and is ideal for applications requiring high integration, small size, and low power. It also is available in 8-Pin SOIC and 8-Pin PDIP packages.

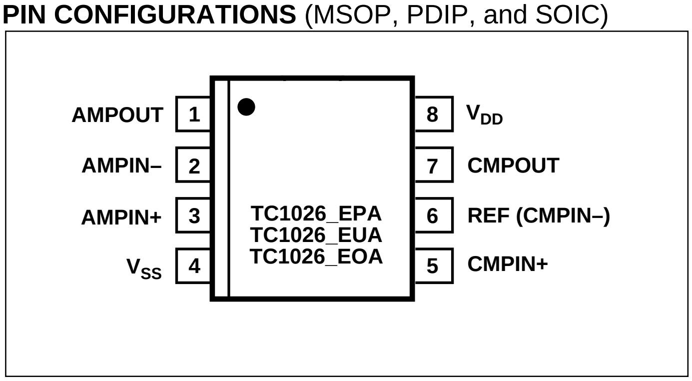
FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part No.	Package	Temp. Range
TC1026CEPA	8-Pin PDIP (Narrow)	– 40°C to +85°C
TC1026CEUA	8-Pin MSOP	– 40°C to +85°C
TC1026CEOA	8-Pin SOIC (Narrow)	– 40°C to +85°C
TC1043EV Evaluation Kit for Linear Building Block Family		

PIN CONFIGURATIONS (MSOP, PDIP, and SOIC)



ABSOLUTE MAXIMUM RATINGS*

Supply Voltage 6.0V
Package Power Dissipation:
8-Pin PDIP (Narrow) ....730 mW
8-Pin SOIC ....470 mW
8-Pin MSOP (Narrow) ....320 mW
Voltage on Any Pin: (With Respect to Supplies)
.... (V_{SS} – 0.3V) to (V_{DD} +0.3V)
Operating Temperature Range:
.... – 40°C to + 85°C
Storage Temperature Range .... – 55°C to +150°C
Lead Temperature (Soldering, 10 sec) .... +260°C

* Static-sensitive device. Unused devices must be stored in conductive material. Protect devices from static discharge and static fields. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating Conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: T_A = –40° to +85°C,and V_{DD} = 1.8V to 5.5V, unless otherwise specified. Typical values apply at 25°C and V_{DD}=3.0V.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{DD}	Supply Voltage		1.8	—	5.5	V
I_Q	Supply Current	All outputs unloaded	—	12	18	µA
Op Amp						
A_{VOL}	Large Signal Voltage Gain	R_L = 10 KΩ, V_{DD} = 5V	—	100	—	V/mV
V_{ICMR}	Common Mode Input Voltage Range		V_{SS} – 0.2	—	V_{DD} +0.2	V
V_{OS}	Input Offset Voltage	V_{DD} = 3V, V_{CM} = 1.5V, T_A = 25°C, T_A = –40°C to 85°C		±100 ±0.3	±500 ±1.5	µV mV
I_B	Input Bias Current	T_A = 25°C, V_{CM} = V_{DD} to V_{SS}	–100	50	100	pA
$V_{OS\ (DRIFT)}$	Average Input Offset Voltage Drift	V_{DD} = 3V, V_{CM} = 1.5V	—	4	—	µV/°C
GBWP	Gain-Bandwidth Product	V_{DD} = 1.8V to 5.5V; V_O = V_{DD} to V_{SS}	—	90	—	KHz
SR	Slew Rate	C_L = 100pF R_L = 1MΩ to GND Gain = 1 V_{IN} = V_{SS} to V_{DD}	—	35	—	mV/µsec
V_{OUT}	Output Signal Swing	R_L = 10 KΩ	V_{SS}+ 0.05	—	V_{DD}– 0.05	V
CMRR	Common Mode Rejection Ratio	T_A = 25°C, V_{DD} = 5V V_{CM} = V_{DD} to V_{SS}	66	—	—	dB
PSRR	Power Supply Rejection Ratio	T_A = 25°C,V_{CM} = V_{SS} V_{DD} = 1.8 to 5V	80	—	—	dB
I_{SRC}	Output Source Current	V_{IN+} = V_{DD}, V_{IN-} = V_{SS} Output Shorted to V_{SS} V_{DD} = 1.8V, Gain = 1	3	—	—	mA
I_{SINK}	Output Sink Current	V_{IN+} = V_{SS}, V_{IN-} = V_{DD}, Output Shorted to V_{DD} V_{DD} = 1.8V, Gain = 1	4	—	—	mA
e_n	Input Noise Voltage	0.1 Hz to 10 Hz	—	10	—	µVpp
	Input Noise Density	1KHz	—	125	—	$nV/\sqrt{Hz}$

ELECTRICAL CHARACTERISTICS: (Cont.)

T_A = –40° to +85°C,and V_{DD} = 1.8V to 5.5V, unless otherwise specified. Typical values apply at 25°C and V_{DD} = 3.0V.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Comparator						
V_{IR}	Input Voltage Range		V_{SS} – 0.2	—	V_{DD} +0.2	V
V_{OS}	Input Offset Voltage	V_{DD} = 3V, T_A = 25°C T_A = –40°C to 85°C	–5 –5	—	+5 +5	mV
I_B	Input Bias Current	T_A = 25°C, IN^+ = V_{DD} to V_{SS}	—	—	±100	pA
V_{OH}	Output High Voltage	R_L = 10KΩ to V_{SS}	V_{DD} – 0.3	—	—	V
V_{OL}	Output Low Voltage	R_L = 10KΩ to V_{DD}	—	—	0.3	V
PSRR	Power Supply Rejection Ratio	T_A = 25°C V_{DD} = 1.8V to 5V	60	—	—	dB
I_{SRC}	Output Source Current	IN^+ = V_{DD} Output Shorted to V_{SS} V_{DD} = 1.8V	1	—	—	mA
I_{SINK}	Output Sink Current	IN^+ = V_{SS} Output Shorted to V_{DD} V_{DD} = 1.8V	2	—	—	mA
t_{PD1}	Response Time	100mV Overdrive,C_L = 100pF	—	4	—	µsec
t_{PD2}	Response Time	10mV Overdrive,C_L = 100pF	—	6	—	µsec
Voltage Reference						
V_{REF}	Reference Voltage		1.176	1.200	1.224	V
$I_{REF(SOURCE)}$	Source Current		50	—	—	µA
$I_{REF(SINK)}$	Sink Current		50	—	—	µA
$C_{L(REF)}$	Load Capacitance		—	—	100	pF
N_{VREF}	Voltage Noise	100 Hz to 100 KHz	—	20	—	µVRMS
	Noise Density	1 KHz	—	1.0	—	$\mu V/\sqrt{Hz}$

DETAILED DESCRIPTION

The TC1026 is one of a series of very low-power, linear building block products targeted at low-voltage, single-supply applications. The TC1026 minimum operating voltage is 1.8V, and typical supply current is only 12µA. It combines a comparator, an op amp, and a voltage reference in a single package.

Comparator

The TC1026 contains one comparator. The comparator's input range extends beyond both supply voltages by 200mV and the outputs will swing to within several millivolts of the supplies depending on the load current being driven. The inverting input is internally connected to the output of the reference.

The comparator exhibits propagation delay and supply current which are largely independent of supply voltage. The low input bias current and offset voltage make it suitable for high impedance precision applications.

Operational Amplifier

The TC1026 contains one rail-to-rail op amp. The amplifier's input range extends beyond both supplies by 200mV and the outputs will swing to within several millivolts of the supplies depending on the load current being driven.

The amplifier design is such that large signal gain, slew rate and bandwidth are largely independent of supply voltage. The low input bias current and offset voltage of the TC1026 make it suitable for precision applications.

Voltage Reference

A 2.0 percent tolerance, internally biased, 1.20V bandgap voltage reference is included in the TC1026. It has a push-pull output capable of sourcing and sinking at least 50µA.

TYPICAL APPLICATIONS

The TC1026 lends itself to a wide variety of applications, particularly in battery-powered systems. It typically finds application in power management, processor supervisory, and interface circuitry.

External Hysteresis (Comparator)

Hysteresis can be set externally with three resistors using positive feedback techniques (see Figure 1). The design procedure for setting external comparator hysteresis is as follows:

1. Choose the feedback resistor R_C. Since the input bias current of the comparator is at most 100 pA, the current through R_C can be set to 100 nA (i.e. 1000 times the input bias current) and retain excellent accuracy. The current through R_C at the comparator's trip point is V_R / R_C where V_R is a stable reference voltage.

2. Determine the hysteresis voltage (V_{HY}) between the upper and lower thresholds.

3. Calculate R_A as follows.

$$R_A = R_C \left(\frac{V_{HY}}{V_{DD}} \right)$$

Equation 1.

4. Choose the rising threshold voltage for V_{SRC} (V_{THR}).

5. Calculate R_B as follows:

$$R_B = \frac{1}{\left[\left(\frac{V_{THR}}{(V_R * R_A)} \right) - \frac{1}{R_A} - \frac{1}{R_C} \right]}$$

Equation 2.

6. Verify the threshold voltages with these formulas:

V_{SRC} rising:

$$V_{THR} = (V_R)(R_A) \left[\left(\frac{1}{R_A} \right) + \left(\frac{1}{R_B} \right) + \left(\frac{1}{R_C} \right) \right]$$

Equation 3.

V_{SRC} falling:

$$V_{THF} = V_{THR} - \left[\frac{(R_A * V_{DD})}{R_C} \right]$$

Equation 4.

Precision Battery Monitor

Figure 2 is a precision battery low/battery dead monitoring circuit. Typically, the battery low output warns the user that a battery dead condition is imminent. Battery dead typically initiates a forced shutdown to prevent operation at low internal supply voltages (which can cause unstable system operation).

The circuit of Figure 2 uses two TC1026 devices and only six external resistors. AMP 1 is a simple buffer while CMPTR1 and CMPTR2 provide precision voltage detection using V_R as a reference. Resistors R2 and R4 set the detection threshold for $\overline{\text{BATT LOW}}$ while resistors R1 and R3 set the detection threshold for $\overline{\text{BATT FAIL}}$. The component values shown assert $\overline{\text{BATT LOW}}$ at 2.2V (typical) and $\overline{\text{BATT FAIL}}$ at 2.0V (typical). Total current consumed by this circuit is typically 28 µA at 3V. Resistors R5 and R6 provide hysteresis for comparators CMPTR1 and CMPTR2, respectively.

Voice Band Receive Filter

The majority of spectral energy for human voices is in a 2.7 KHz frequency band from 300 Hz to 3 KHz. To properly recover a voice signal in applications such as radios, cellular phones, and voice pagers, a low-power bandpass filter that is matched to the human voice spectrum can be implemented using TelCom's CMOS op amps. Figure 3 shows a unity-gain multi-pole Butterworth filter with ripple less than 0.15 dB in the human voice band. The lower 3 dB cut-off frequency is 70 Hz (single-order response), while the upper cut-off frequency is 3.5 KHz (fourth-order response).

Supervisory Audio Tone (SAT) Filter for Cellular

Supervisory Audio Tones (SAT) provide a reliable transmission path between cellular subscriber units and base stations. The SAT tone functions much like the current/voltage used in land line telephone systems to indicate that a phone is off the hook. The SAT tone may be one of three frequencies: 5970, 6000, or 6030 Hz. A loss of SAT implies that channel conditions are impaired, and if SAT is interrupted for more than 5 seconds, a cellular call is terminated.

Figure 4 shows a high Q (30) first order SAT detection bandpass filter using TelCom's CMOS op amp architecture. This circuit nulls all frequencies except the three SAT tones of interest.

EVALUATION KIT

The TC1043EV consists of a four-inch by six-inch prewired application circuit board. Pre-configured circuits include a pulse width modulator, wake-up timer, function generator, and others. On-board current meter terminals, voltage regulator, and a user-prototyping area speed circuit development. Please contact your local Microchip Technologies representative for more information.

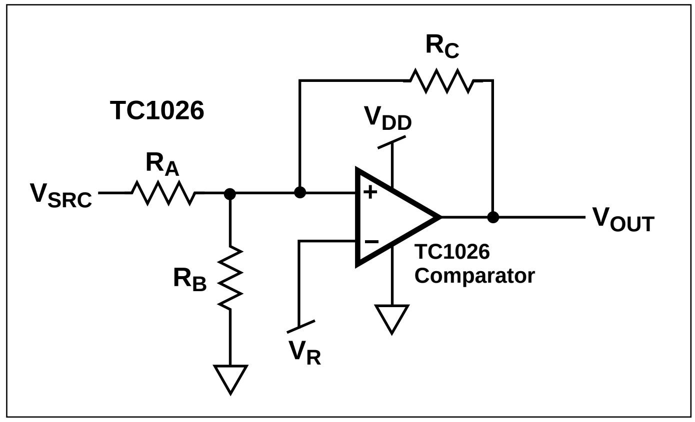


Figure 1. Comparator External Hysteresis

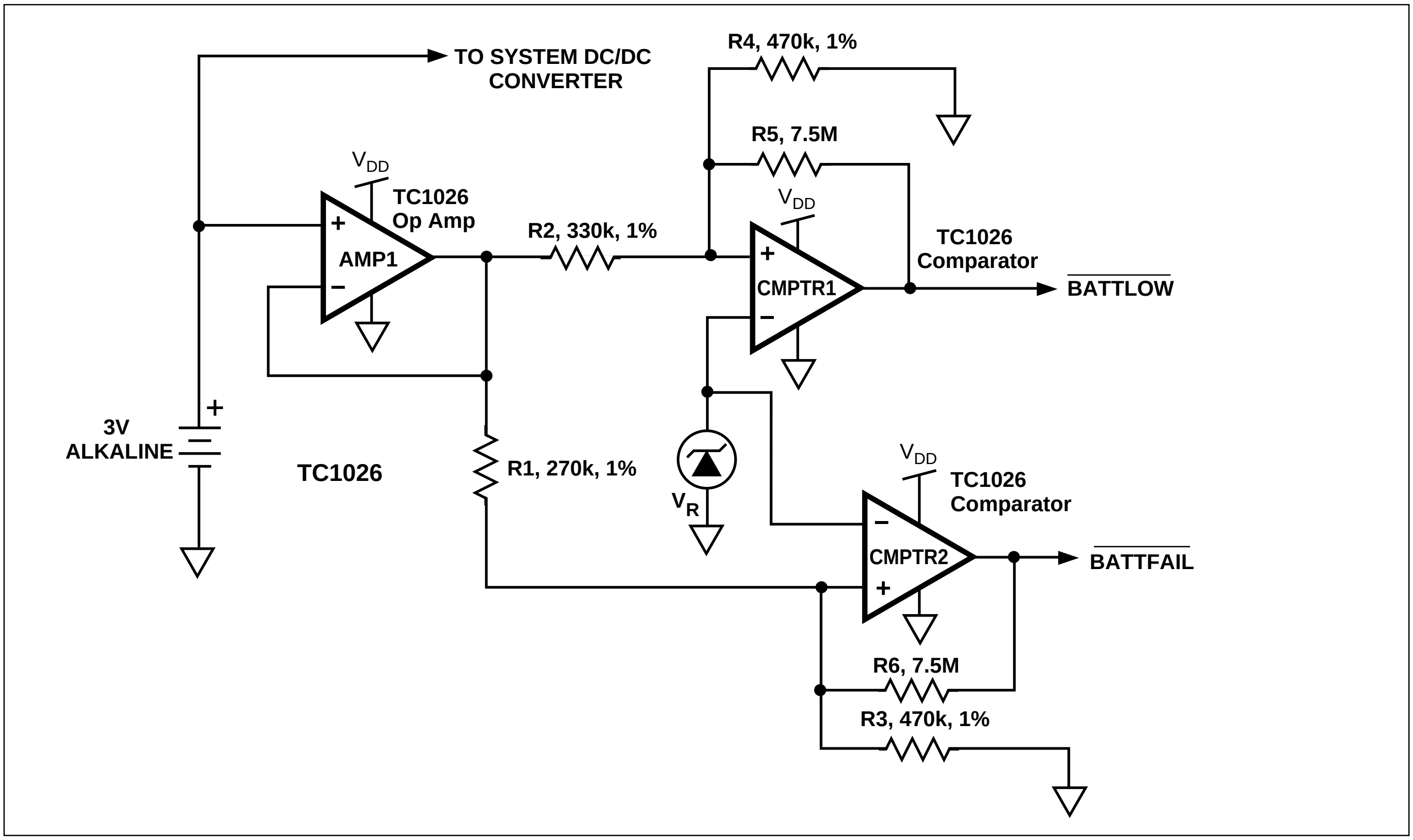


Figure 2. Precision Battery Monitor

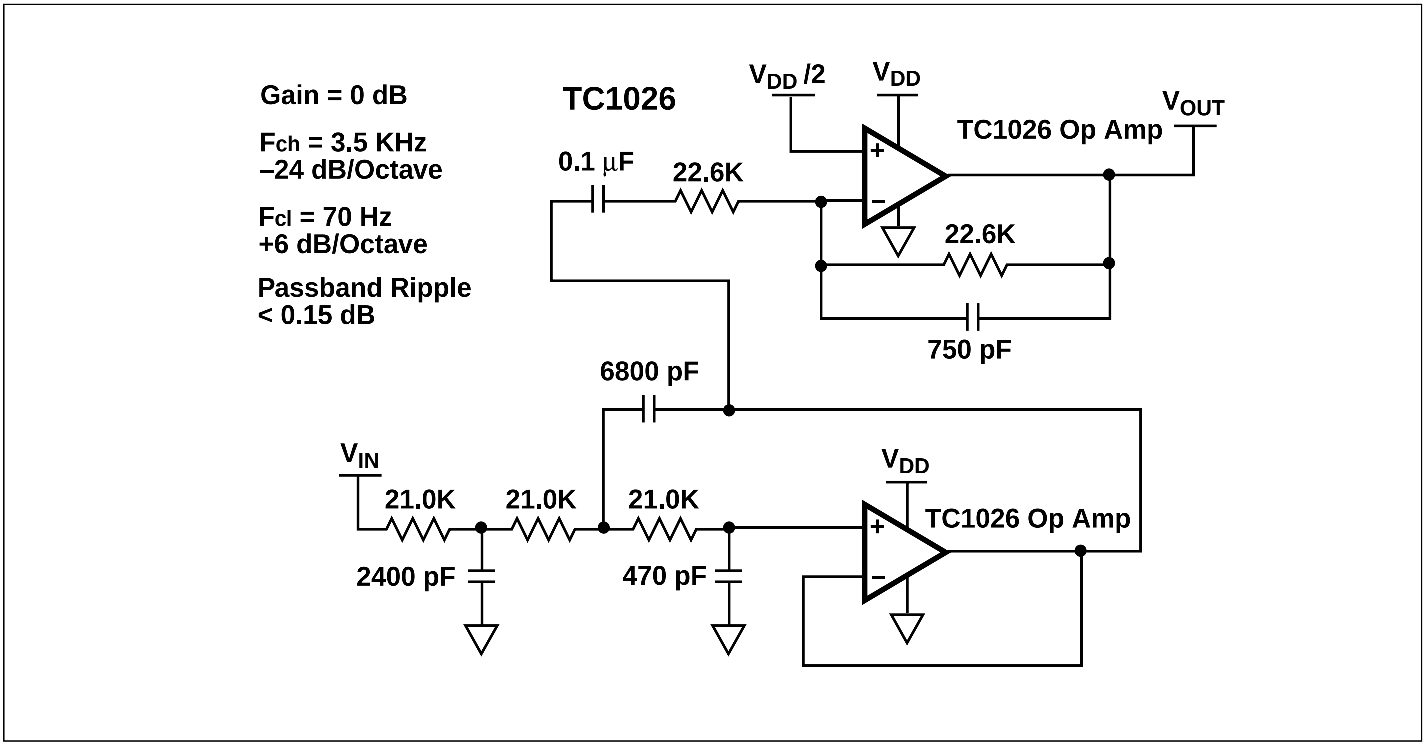


Figure 3. Multi-Pole Butterworth Voice Band Receive Filter

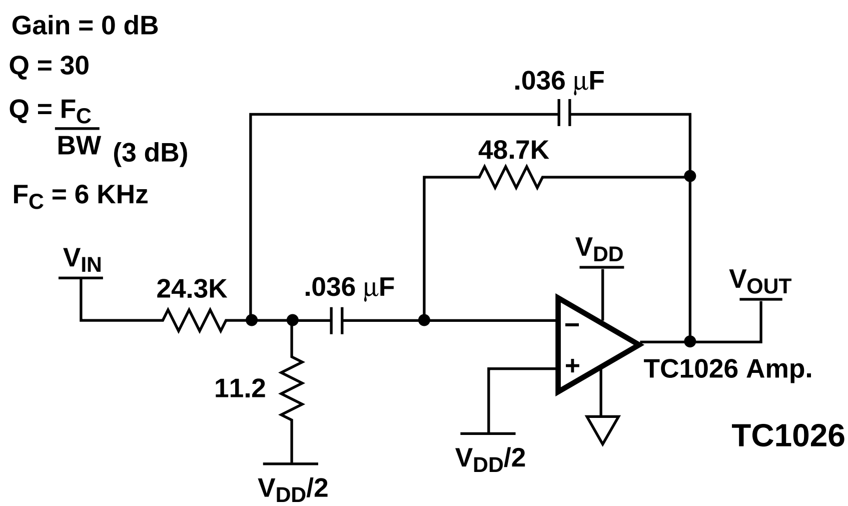
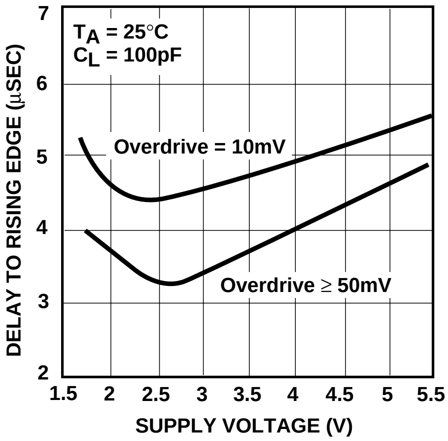


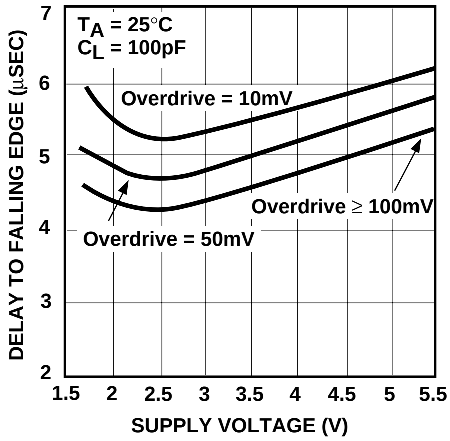
Figure 4. Second Order SAT Bandpass Filter

TYPICAL CHARACTERISTICS

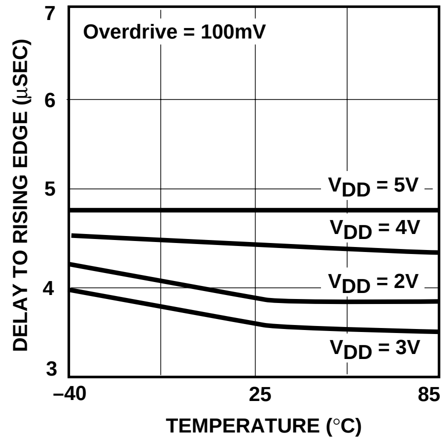
Comparator
Propagation Delay vs. Supply Voltage



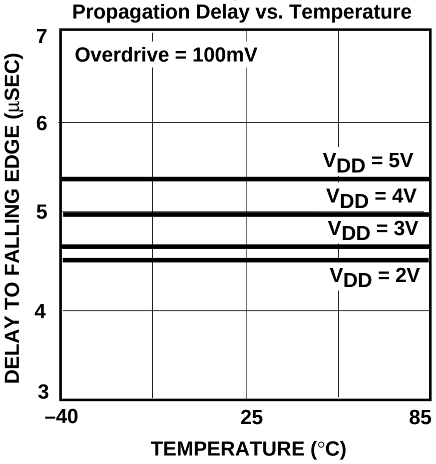
Comparator
Propagation Delay vs. Supply Voltage



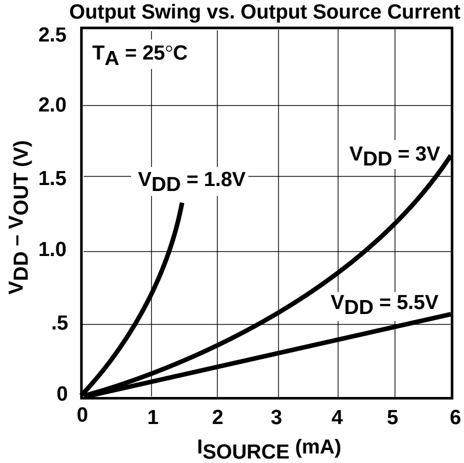
Comparator
Propagation Delay vs. Temperature



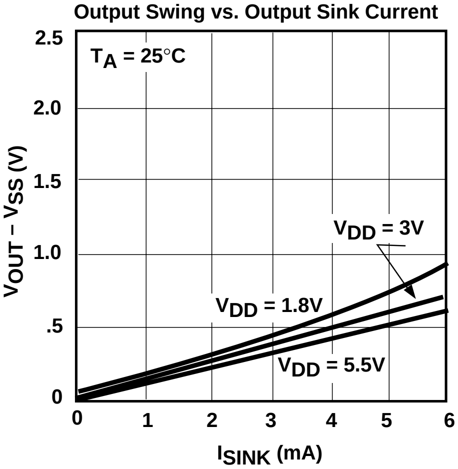
Comparator
Propagation Delay vs. Temperature



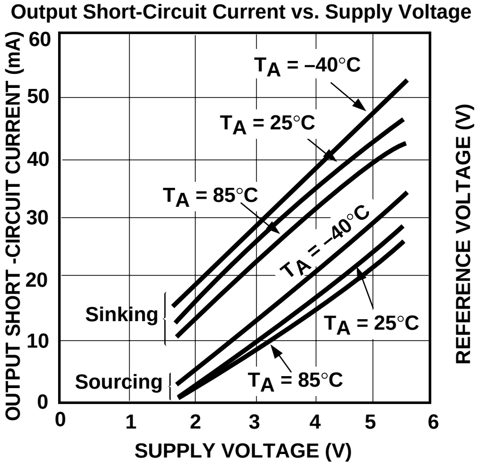
Comparator
Output Swing vs. Output Source Current



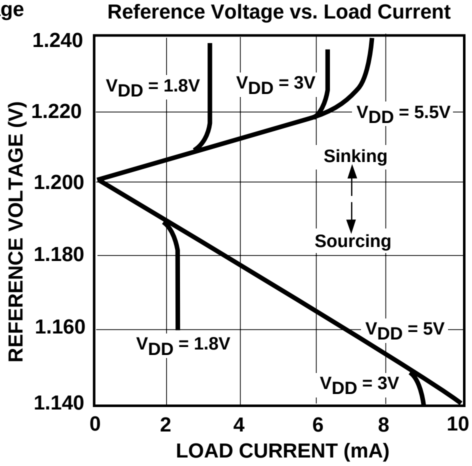
Comparator
Output Swing vs. Output Sink Current



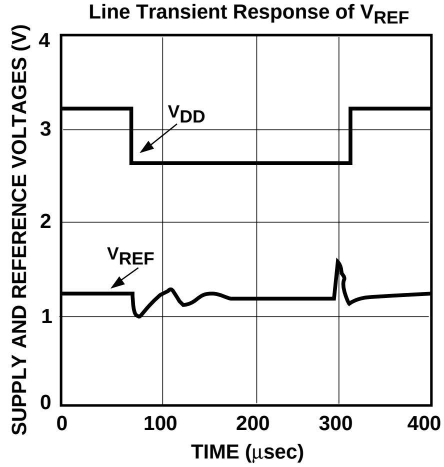
Comparator
Output Short-Circuit Current vs. Supply Voltage



Reference Voltage vs. Load Current

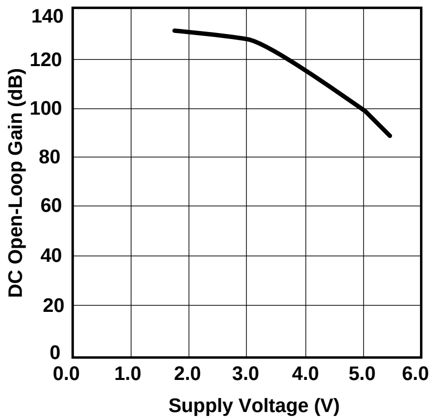


Line Transient Response of V_{REF}

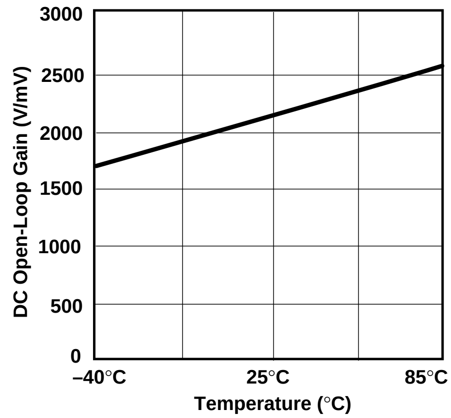


TYPICAL CHARACTERISTICS

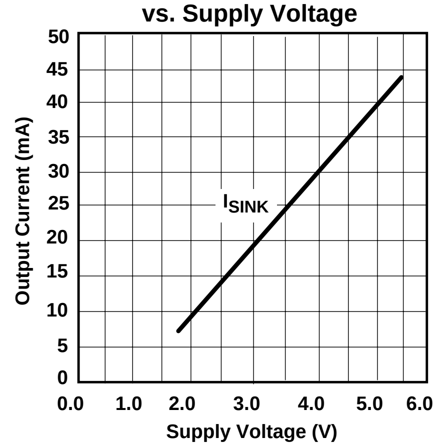
**Op Amp
DC Open-Loop Gain
vs. Temperature**



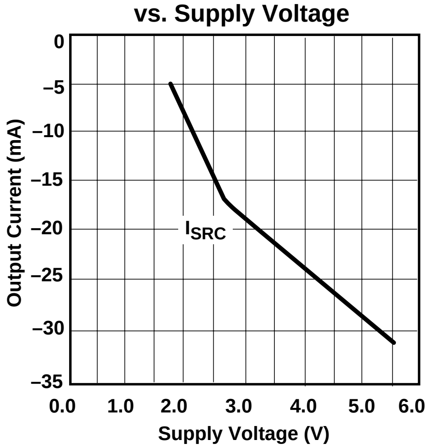
**Op Amp
DC Open-Loop Gain
vs. Temperature**



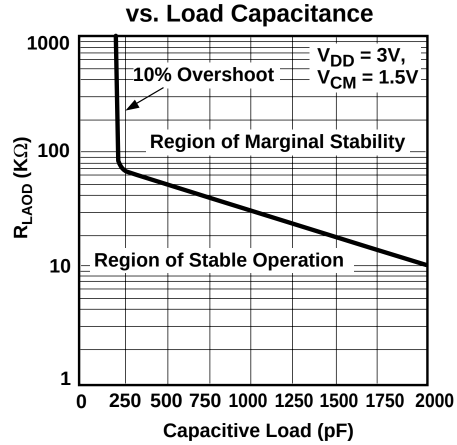
**Op Amp
Short-Circuit Current
vs. Supply Voltage**



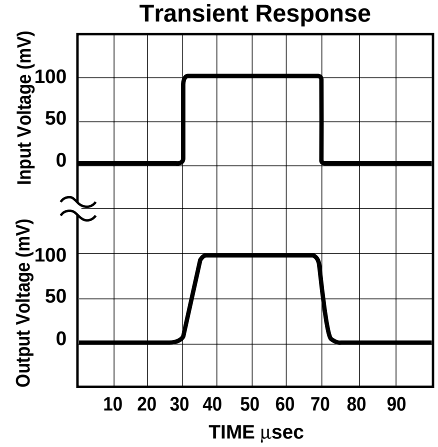
**Op Amp
Short-Circuit Current
vs. Supply Voltage**



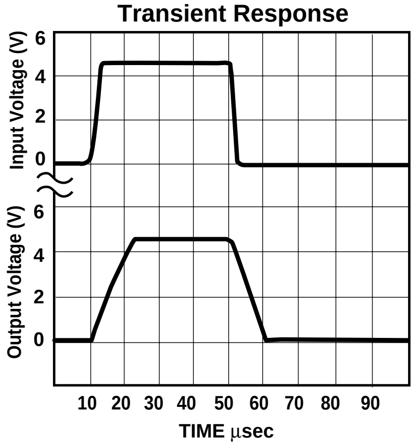
**Op Amp
Load Resistance
vs. Load Capacitance**



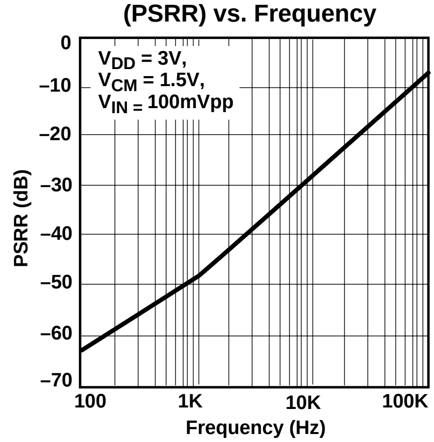
**Op Amp Small-Signal
Transient Response**



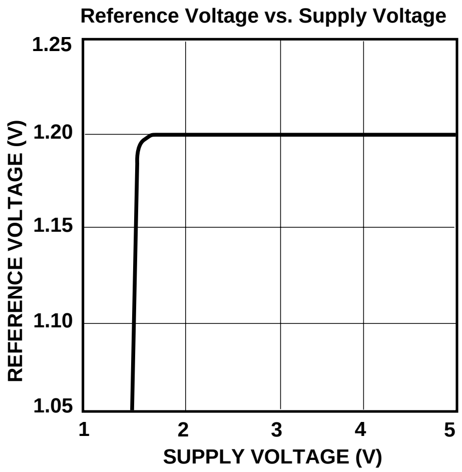
**Op Amp Large-Signal
Transient Response**

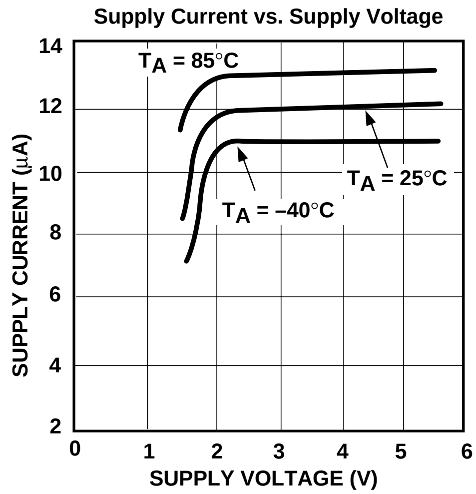


**Op Amp
Power Supply Rejection Ratio
(PSRR) vs. Frequency**

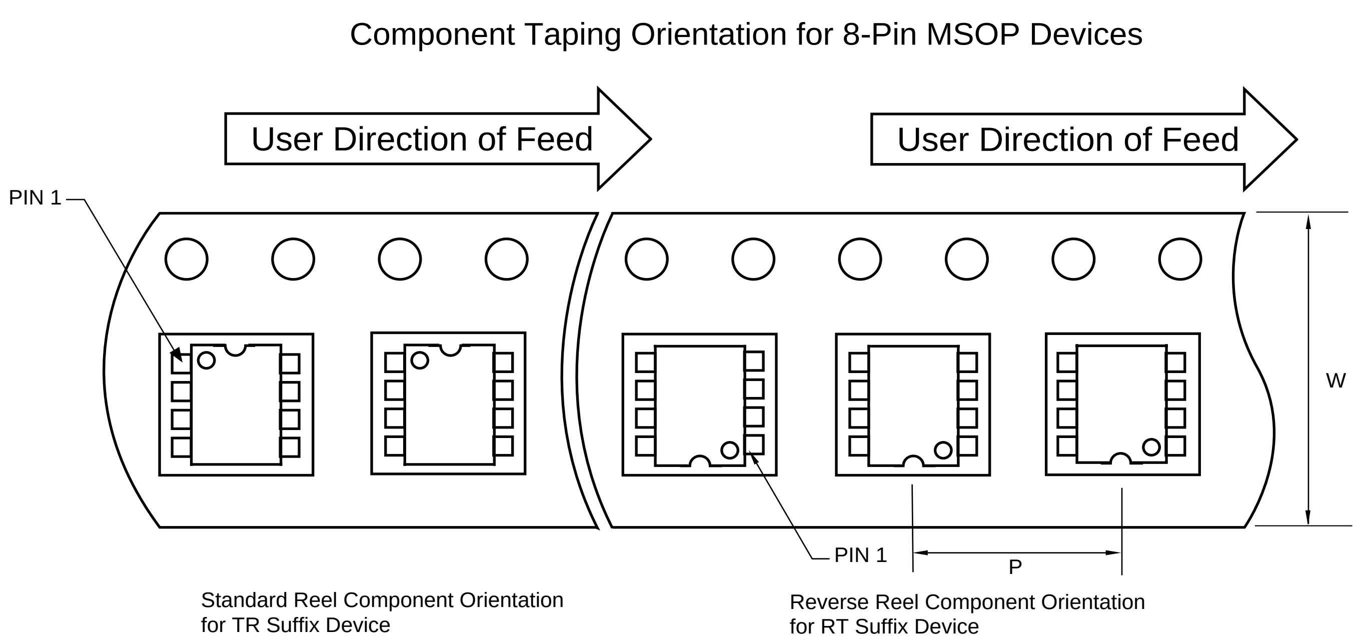


TYPICAL CHARACTERISTICS





TAPING FORM

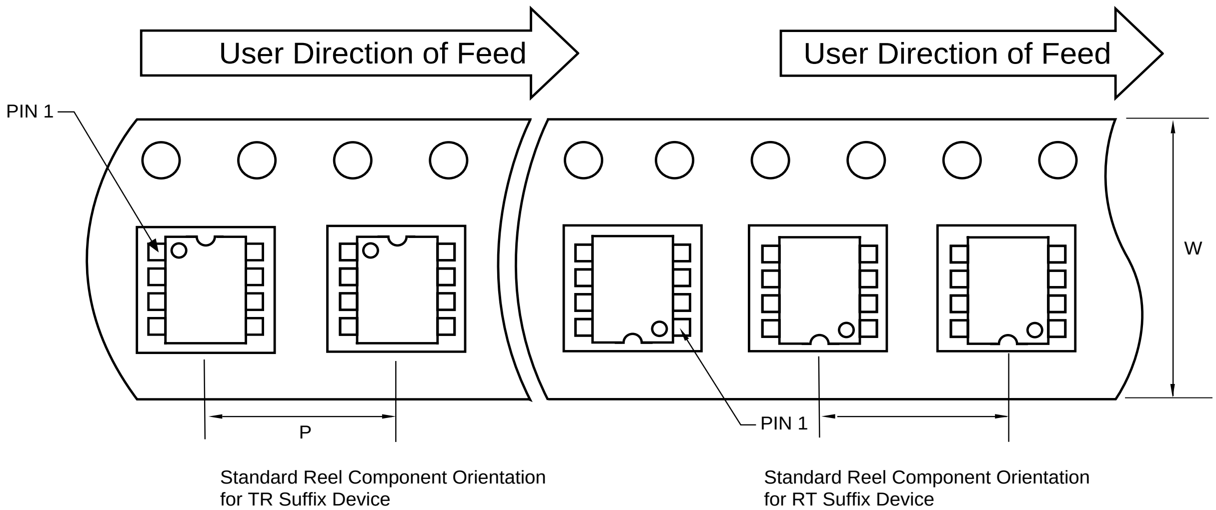


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin MSOP	12 mm	8 mm	2500	13 in

TAPING FORM (CONT.)

Component Taping Orientation for 8-Pin SOIC (Narrow) Devices

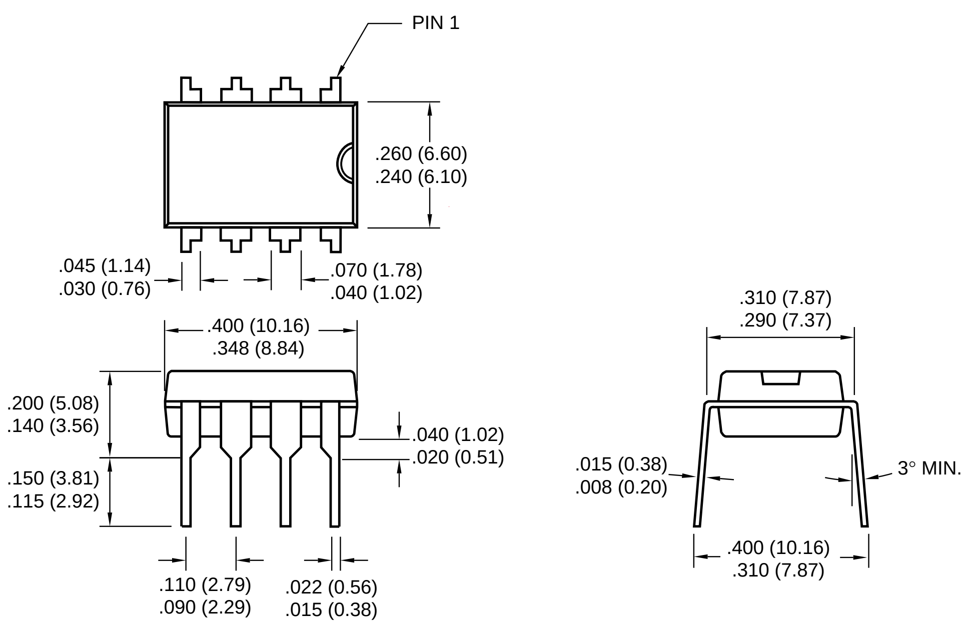


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
8-Pin SOIC (N)	12 mm	8 mm	2500	13 in

PACKAGE DIMENSIONS

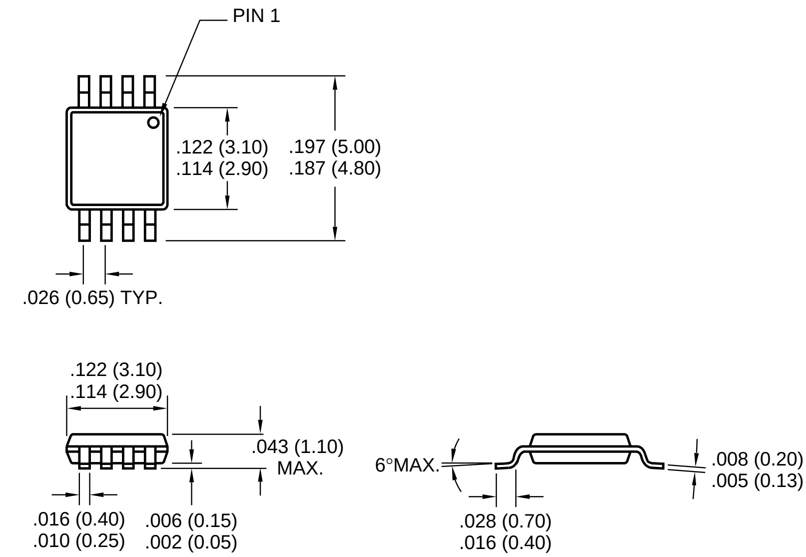
8-Pin PDIP (Narrow)



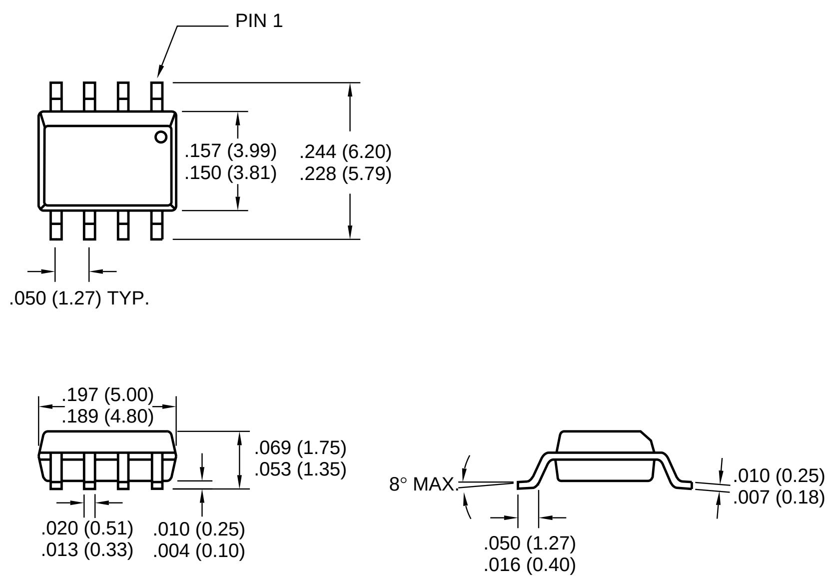
Dimensions: inches (mm)

PACKAGE DIMENSIONS (CONT.)

8-Pin MSOP



8-Pin SOIC (Narrow)



Dimensions: inches (mm)

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